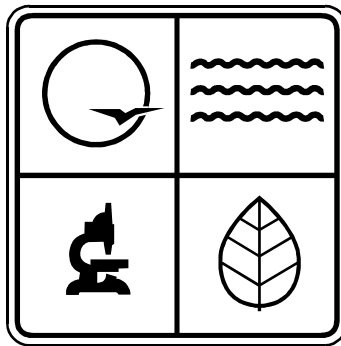


MISSOURI
WATER QUALITY REPORT

2000

MISSOURI DEPARTMENT OF NATURAL RESOURCES



WATER POLLUTION CONTROL PROGRAM

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CHAPTER 1. EXECUTIVE SUMMARY

WATER RESOURCES AND PROBLEMS

Missouri has an area of 69,000 square miles and a population of 5.44 million people. Most of the human population is concentrated on opposite sides of the state in the Kansas City and St. Louis metro areas, leaving most of the state and its waters rural in nature. Surface and ground water in Missouri are quite varied in quantity and quality, corresponding closely with geology and land use.

Northern and Western Missouri

Northern and Western Missouri, originally prairie land, is now used primarily for crop and livestock production and is underlain by bedrock containing several relatively impermeable shale and clay layers. Surface waters are more turbid and are greatly affected by high rates of sediment deposition. These deposits, caused by soil erosion and channelization, result in poor aquatic habitat due to the fine, unstable materials of stream bottoms. About 7,300 miles of classified streams suffer impairment due to these conditions, and, in more than half these miles, streams are further impaired by either periodic water loss or channelization.

Rivers and reservoirs used as drinking water supplies often contain herbicides. Drinking water standards for atrazine or health advisory levels for cyanazine are exceeded in some public water supplies served by reservoirs. Several other herbicides are occasionally found in drinking water reservoirs but at concentration below health advisory levels.

The quality of ground waters in northern and western Missouri is also influenced by the geology of the area. The public water supply sources include reservoirs and wells. The wells obtain water from glacial drift deposits primarily in portions of north-central and western Missouri. Wells in western Missouri, south of Kansas City, obtain water from limestone aquifers except for the extreme western limits of Missouri near the state border with Kansas. Private water supplies are obtained from glacial drift deposits and from underlying limestone bedrock in portions of northwestern, central, eastern and northeastern Missouri. However, deep bedrock wells in many north-central and northwestern Missouri locations tap water supplies too mineralized for drinking water purposes. About one-third of private wells in this portion of Missouri exceed the drinking water standard for nitrate, and about 2 percent exceed drinking water standards for pesticides. This contamination is often caused by localized surface contamination of the wellhead and does not represent widespread contamination of the underground aquifer. Deeper aquifers are well protected from surface contamination by impermeable strata.

The Ozark Plateau

The Ozark Plateau, including the Springfield Plateau, is predominantly hilly topography. There are some very rugged portions as well as significant areas of gentle to almost flat landscape. The bedrock consisting of limestone, dolomite and sandstone yields ground water of excellent quality and adequate in supply for most urban, industrial and other needs. The soil or overburden has developed by weathering from the bedrock formations and is generally 20 to 80 feet in thickness.

Some areas have extremely thin soils and other locations where weathering has been extensive have thickness of 100 feet and more. The soil overburden has moderate to high infiltration rates which contribute to the recharge of ground water supplies. Ozark streams are generally clear with baseflows well sustained by many seeps and springs. Some streams and reservoirs in the Ozarks are becoming nutrient and algae enriched due to increasing human and domestic animal production in some watersheds.

Ground water contamination risks are moderate to high due to the permeabilities of the soil and bedrock. Any number of surface activities including agricultural and suburban-urban storm water and waste water disposal, mining, stormwater runoff, lawn care, and improper well and individual waste disposal practices all pose threats to surface water and ground water quality. However, overall water quality remains good in large part due to the efforts by all parties to protect the aquifers.

Ground water is heavily relied upon for drinking water supply in this part of Missouri. Most municipalities in the southern half of the state rely on ground water for drinking water supply. The number of private drinking water wells state-wide is not known but probably is between 100,000 and 250,000 with a greater number of these wells being south of the Missouri River. The major ground water concern is the often rapid and unfiltered transmission of contaminated surface runoff or leachate from some septic tanks, underground storage tanks, landfills, dumps, liquid waste storage ponds, animal production and processing wastes through fractures or sinkholes directly into potable aquifers. Properly cased wells into deep aquifers rarely encounter water quality problems, but shallow or improperly cased wells are at risk.

In the Joplin area, the shallow bedrock aquifer has elevated levels of sulfate and several heavy metals due to mineralization of ground water in flooded mines. Some private wells in this area exceed drinking water standards for lead or cadmium. Localized contamination of shallow private wells due to leaks, spills and improper disposal of industrial or commercial chemicals occur in the larger metro areas of Springfield and Joplin.

The Mississippi Embayment

Missouri's southeastern corner is a large alluvial plain of the Mississippi River. Originally a vast system of wetlands, it has been drained and almost entirely converted to crop production. Almost all surface waters in the area are drainage ditches and are rated as only partially attaining beneficial uses because of degradation of aquatic habitat due to channelization. Channelization creates a homogenous, low quality aquatic habitat. Sloughing of the channel banks, which fill the channel bottoms, burying better habitat and leaving unstable substrate, is a problem.

Ground water is abundant due to high infiltration rates on these flat fields. Public water supplies that tap deeper aquifers provide good quality water, but shallow private wells commonly have nitrates and low levels of pesticides. The frequency of exceedence of drinking water standards for nitrates and pesticides in private wells is similar to northern Missouri, about 30 percent and 2 percent, respectively.

Alluvial Aquifers

The remaining major aquifer is the alluvial aquifer system of the major rivers of the state. In northern Missouri, where surface and deep aquifer supplies are unreliable, many towns depend on the alluvial aquifer of a large nearby stream. Landfills and industrial land use in Kansas City and St. Louis have historically been located on river floodplains and have caused local contamination of the Mississippi, Missouri and Meramec river aquifers in St. Louis and the Missouri River aquifer in Kansas City. Some municipal water supplies have been affected.

WATER POLLUTION CONTROL ACTIVITIES

Authority for enforcement of the Missouri Clean Water Law and for state regulations concerning water pollution resides in the Department of Natural Resources, Division of Environmental Quality. Authority for the regulation of pesticides rests with the Missouri Department of Agriculture.

Point Source Controls

The number of miles of classified streams impaired by point source wastewater discharges has generally been decreasing since 1984, when state-wide data on stream quality became available. In 1984, 105 miles of classified stream were impaired by domestic or industrial waste waters, and only 42 miles in 1996, but that figure increased to 91 miles in 1998. This was due mainly to increased loads at the California South lagoons and elevated fecal coliform bacteria below the Springfield NW wastewater plants. These two discharges are estimated to impair 39 miles of stream.

The Missouri Clean Water Commission has revised its regulations to bring confined animal feeding operations (CAFOs) into the point source permit program, consistent with federal requirements. There has been unprecedented growth in CAFOs in Missouri during the past few years. Where manure spills and fish kills from CAFOs occur, there can be serious water quality problems. This report notes 18.7 miles of classified streams polluted by chronic manure spills. Assuring proper management of animal manure is a high priority of the department.

Nonpoint Source Controls

Control of nonpoint water pollution sources such as runoff from farms, cities, mining areas and construction sites is still essentially a voluntary program. Regulations are in place to prevent leakage from underground storage tanks and for the secondary containment of bulk agricultural chemical storage sites. Large sand and gravel mining operations require a general permit for storm water and smaller operations have been provided with guidelines for best management practices (BMPs), in addition to the 404 permit required of all sand and gravel operations. Control of many nonpoint sources, such as agricultural erosion from cropland and pasture, runoff of fertilizer, pesticides and animal waste, are addressed by Missouri's nonpoint source management program. This program works with federal, state and local governments, universities, private groups and individual landowners to implement watershed projects that demonstrate nonpoint source control practices and often monitor water quality results.

Programs with dedicated funding sources have worked best. A tax on coal has funded reclamation of abandoned coal mined lands nationwide. Fourteen years of such reclamation in Missouri has reduced the number of stream miles impaired by acid mine drainage from about 100 down to 42. A state sales tax for soil erosion control started providing funds for watershed level soil erosion control programs in 1985. This program, coupled with federal soil conservation programs, is reducing soil erosion in Missouri based on the findings of periodic National Resource Inventories.

STATE CONCERNS

- Channelization has caused aquatic habitat degradation in 17 percent of Missouri's streams. [Large channelization projects affecting many miles of streams are no longer occurring but many short projects still occur and continue to reduce the number of miles of natural stream channels state-wide.](#) Streams that were channelized many years ago still provide poor aquatic habitat, and these streams still contribute to flooding, high water velocities and streambank erosion.
- Eutrophication of large, recreationally important reservoirs appears to be increasing. Heavy residential development around portions of Lake of the Ozarks and Table Rock Lake threatens water quality in many small coves and shoreline areas. Water clarity in the main portion of Table Rock Lake, which was historically very clear, is apparently declining. The large size of these lakes and rugged local topography make centralized collection and treatment systems for wastewater difficult. Nutrient problems from waste water treatment plants and septic tanks are being aggravated by increasing confined animal production in the watersheds of these lakes.
- Mercury levels in fish in Arkansas and Missouri appear to be increasing over time, with fish consumption health advisories in place in southern Arkansas. Atmospheric deposition is suspected as a major cause.
- Abandoned lead-zinc mines and their tailings continue to impact waters decades after mining has ceased. Missouri's Superfund program is addressing some of these concerns. But, long-term impacts are expected to remain. Although new mineral extraction operations would be managed under state permits, areas of the state that are very sensitive to disruption are being investigated for mining potential.
- Additional ground water protection measures are needed. Missouri now has in place programs that register and inspect underground storage tanks and oversee the cleanup of leaking underground tank sites, programs for wellhead protection, sealing of abandoned wells and closing of hazardous waste sites. A complete ground water protection program would also include a ground water monitoring network and educational programs for those involved in the application of farm chemicals, transporters of hazardous materials and the general public.

- Large confined animal feeding operations (CAFOs) continue to be located in Missouri. These facilities generate large amounts of animal manure and have the potential to cause serious water pollution problems. We are also concerned by cumulative impacts of numerous small animal production facilities.
- Evidence is accumulating that the fish and invertebrate communities of many streams in Missouri are suffering from the degraded quality of the aquatic habitat. Physical alterations of the channel, degraded conditions in the riparian zone and upland land use changes are all believed to be significant contributors to this problem.
- Continuing suburban development impacts streams by direct loss of stream channels by shortening, culverting, removal of riparian areas and other impacts associated with development and increased storm water flows.

TABLE 1. BENEFICIAL USE SUPPORT STATUS OF MISSOURI CLASSIFIED* WATERS

STATUS	STREAM MILES	%	LAKE ACRES	%
Full Support	11,132.9	51	132,002	45
Full but Threatened	224.7	1	143,792	49
Partial Support	10,012.5	45	11,547	4
Not Supported	476.8	2	5894	2
Not Assessed	219	1	0	0

Full Support: Water quality meets the needs of all uses that Missouri recognizes for a particular waterbody such as protection of fish and other aquatic life (the water quality does not interfere with the ability of aquatic life to live, feed and reproduce), livestock and wildlife watering (the water will not cause disease or injury to livestock and wildlife using the water for drinking), drinking water supply (the water meets all state and federal standards as a drinking water supply source water), swimming (the water will not cause disease or injury to swimmers or others participating in water-based recreation who may accidentally swallow small amounts of water), irrigation (the water will not cause disease or injury to crops) or industrial water supply (the water will not cause excessive problems with corrosivity or mineral deposits in industrial piping and boilers), fish consumption (fish are safe to eat) and boating and canoeing.

Threatened: Water quality is presently adequate to maintain all recognized uses, but, if harmful trends continue, only partial support may exist in the future.

Partial Support: Water quality has been impaired to the point that at least one of the recognized uses is affected.

Not Supported: Water quality is seriously affected to the point that at least one recognized uses of the waterbody has been lost.

Not Assessed: Streams in some urban and rural watersheds are believed to be significantly different in land use from monitored streams in their region so that their quality cannot be accurately inferred from monitored streams.

NOTE: In this report, "impaired" waters refers to waters rated as partial support or not supported.

* There are 22,065 miles of classified streams (permanently flowing streams or streams which maintain permanent pools during dry weather) and approximately 30,000 miles of unclassified streams (streams which are without water during dry weather). There are 293,305 surface acres of classified lakes. The number of surface acres of small unclassified lakes has not been estimated.

TABLE 1A. INDIVIDUAL USE SUPPORT SUMMARY FOR CLASSIFIED STREAMS

BENEFICIAL USE	SIZE ASSESSED	FULL SUPPORT	PARTIAL SUPPORT	NON-SUPPORT	NOT ASSESSED	USE NOT APPLICABLE
STREAMS (MILES)						
AQUATIC LIFE	21,600.2	11,398.9	9,973.3	228.1	458.1	0
FISH CONSUMPTION	21,836.5	21,671.4	8.2	156.9	221.8	0
SWIMMING	5,400.5	5,348.8	4.3	47.4	0	16,657.8
DRINKING WATER	3,185.7	2,975.2	0.0	210.5	0	18,872.6
LAKES (ACRES)						
AQUATIC LIFE	293,235	291,455	50	1730	0	0
FISH CONSUMPTION	293,235	292,295	0	940	0	0
SWIMMING	261,847	261,715	0	132	542	30,846
DRINKING WATER	89,857	85,287	1478	3092	0	203,378

TABLE 2. MAJOR WATER POLLUTION SOURCES IN MISSOURI CLASSIFIED WATERS
(Stream Miles or Lake Acres Impaired)

Source	Stream Miles Impaired	Percent of Total Miles	Lake Acres Impaired	Percent of Total Acres
Agriculture	7,624.4	34%	4,566	2%
Crop Production/Grazing	7,602.3	34%	4,566	2%
Pasture	8.5	*	0	
Hydromodification	3,758.9	17%	11,780	4%
Channelization	3,697.9	17%		
Flow Regulation/Modific.	39.0	*	11,780	4%
Streambank Mod./Destab.	21.0	*		
Mining	179.7	1%		
Municipal and other Domestic Point Sources	93.3	*		
Urban Runoff and Construction	56	*	825	*
Industrial Point Sources	2.7	*		
Landfills	0.3	*		
Recreational Activities	1	*		
Atmospheric Deposition	5.5	*		
Natural Sources	162.5	1%	70	*
Unknown	2	*	615	*

* less than 1 %

TABLE 3. MAJOR CONTAMINANTS IN MISSOURI CLASSIFIED WATERS

Contaminant	Stream Miles Impaired	% of Total Miles	Lake Acres Impaired	% of Total Acres
Sediment	7,478.1	34	--	--
Habitat Degradation	3,629.4	16	--	--
Organic Enrichment /Low D.O.	55.9	*	1780	1
Metals	337.5	2	10,000	3
Bacteria	45.5	*	615	*
Ammonia	18.2	*	--	--
Pesticides	24	*	3,894	1
Suspended Solids	17	*	--	--
Nutrients	4.3	*	1,478	15
TDS: Sulfate, Chloride	47.0	*	--	--
Flow Alterations			50	*
Toxic Organic Chemicals (other than pesticides)	39.2	*		
pH	14.8	*		
Thermal Modification	1.1	*		
Unknown	19.7	*		

* less than 1 %.

NOTE: Many stream miles in Missouri are affected by more than one pollution source or pollutant; therefore, total miles/acres in Tables 2 and 3 can exceed miles/acres in Table 1.

CHAPTER 2. MISSOURI AND ITS WATER RESOURCES

Missouri has an area of 69,000 square miles and a population of 5.44 million people. Most of the population is concentrated along the border areas on opposite sides of the state in the Kansas City and St. Louis metro areas. Population as well as industrial and commercial activity in major urban areas has remained relatively stable for the past few decades. Patterns of rural land use have changed greatly in some areas, particularly residential development around the larger cities, recreational development adjoining Lake Taneycomo and the eastern ends of Lake of the Ozarks and Table Rock Lake and the increasing development of large animal confined feeding operations in north central and southwestern Missouri.

Missouri has an impressive stream network that includes over 22,000 miles of classified streams and over 293,000 surface acres in its 456 classified lakes. Three distinct regions exist within the state's boundaries, and the particular geology and land use of each affect water quality. These areas are a prairie region, which is rolling land predominately used for row crop and pasture; the Ozarks, a hilly area that is mostly pasture and forest; and the Bootheel, a flat alluvial plain adjoining the Mississippi River in southeast Missouri, which is used mainly for row crop production.

Missouri's Water Quality Standards (10 CSR 20-7.031) provide the names and locations of all classified streams and lakes. This state regulation defines over 3,600 individual stream and river segments and 456 lakes, lists which beneficial uses assigned to each of these waters and defines the level of water quality necessary to meet each of these uses.

The remaining waters of the state--such as those in the upper portions of the stream network that do not have permanently flowing or standing water and a number of small lakes--are not listed in the Missouri Water Quality Standards and do not have beneficial uses assigned to them. These unclassified waters are protected by the general criteria in the Water Quality Standards. The general criteria say these waters must be free from such aesthetic problems as demolition debris, trash, tires, odor, discoloration or the presence of objectionable floating or deposited material. The general criteria also say the waters must be free from conditions harmful to livestock or aquatic life.

TABLE 4. MISSOURI'S WATER RESOURCES

Missouri Population (million people)	5.44
Surface Area (square miles)	69,000
Number of Major Basins	8
Classified Stream Miles	22,065
Unclassified Stream Miles (estimated)	30,000
Number of Classified Lakes	456
Total Classified Lake Surface Area (acres)	293,305
Freshwater Wetlands Area (acres)	643,000

CHAPTER 3. SURFACE WATER ASSESSMENT

DESCRIPTION OF MISSOURI'S CURRENT WATER QUALITY MONITORING PROGRAM

Purpose

The major purposes of the water quality monitoring program are (1) to characterize background or reference water quality conditions; (2) to better understand daily, flow event and seasonal water quality variations and their underlying processes; (3) to characterize aquatic biological communities and habitats and to distinguish between the impacts of water chemistry and habitat quality; (4) to assess time trends in water quality; (5) to characterize the impact of local and regional impacts of point and nonpoint source discharges on water quality; (6) to check for compliance with water quality standards or wastewater permit limits, to develop TMDLs to monitor effectiveness of pollution control activities; and (7) to support development of strategies to return impaired waters to compliance with water quality standards. All of these objectives are state-wide in scope.

Coordination with Other Monitoring Efforts in Missouri

The department cooperates with other agencies in performing special water quality studies.

In 1998, a multi-agency task force including the Missouri Dept. of Natural Resources, Missouri Conservation Department, the US Environmental Protection Agency, the US Geological Survey, the US Forest Service, the US Natural Resource and Conservation Service and the University of Missouri convened to lay out an outline of a state-wide aquatic resources monitoring plan, define partnership roles in this monitoring plan and to discuss the kind of research needed to further this new monitoring effort. The first major product of this work group was an agreement to initiate in 2001, a cooperative state-wide aquatic invertebrate and fish monitoring program by the Missouri Department of Conservation and the Dept. of Natural Resources.

To maximize efficiency, the department routinely coordinates its monitoring activities to avoid overlap with other agencies and provide and receive interagency input on monitoring study design. Data from other sources is used for meeting the same objectives as department sponsored monitoring. The agencies most often involved are the U.S. Geological Survey (USGS), the U.S. Army Corps of Engineers, the U.S. Environmental Protection Agency (EPA), the Missouri Department of Conservation (MDC), the USDA/Agricultural Research Service (ARS) and the Missouri Department of Health. However, the department also tracks the monitoring efforts of the U.S. Park Service, the U.S. Forest Service, several of the state's larger cities, the states of Arkansas, Kansas, Iowa and Illinois and graduate level research conducted at universities within Missouri. The department also uses monitoring data acquired by wastewater dischargers as a condition of discharge permits issued by the department. The department began using data collected by volunteers that have passed Quality Assurance/Quality Control (QA/QC) tests in 1995.

Networks and Programs

1. Fixed Station Network

- A. Objective: To better characterize background or reference water quality conditions, to better understand daily, flow event and seasonal water quality variations and their underlying processes, to assess time trends and to check for compliance with water quality standards.
- B. Design Methodology: Sites were chosen based on one of the following criteria:
- site is believed to have water quality representative of many neighboring streams of similar size due to similarity in watershed geology, hydrology and land use, and the absence of any impact from a local point or discrete nonpoint water pollution source.
 - site is downstream of a significant point source or localized nonpoint source area.
- C. Number of Sites, Sampling Methods, Sampling Frequency, Parameters:
- USGS/DNR cooperative network: 36 sites state-wide, horizontal and vertical integrated grab samples, 6-12 times per year, major ions, nutrient ions, temperature, pH, dissolved oxygen, specific conductance, suspended solids, heavy metals flow 2-4 times annually and pesticides 6 times annually at 6 sites. [The number of sites in this network increased to 63 in 1999.](#)
 - Crowder College network: 6 sites in southwest Missouri, grab samples, monthly, pH, conductance, temperature, total phosphorus, ammonia nitrogen, nitrate plus nitrite, nitrogen, fecal coliform and fecal strep bacteria. [Plans are to expand this monitoring network to nine sites sampled 15 times per year in 2000.](#)
 - DNR raw water sampling of public drinking water reservoirs: 4 sites, grab samples, 4 times/year, common herbicides. [This monitoring network was increased to 20 reservoirs in 1999 and will increase to 31 reservoirs in 2000.](#) UMC/DNR lake monitoring network, circa 100 lakes monitoring during the summer and about 12 monitored spring through fall for nutrients, chlorophyll, turbidity and suspended solids.
 - DNR routine monitoring of finished public drinking water supplies for bacteria and trace contaminants.
 - [Routine bacterial monitoring of swimming beaches at Missouri state parks during the recreational season by DNR, Division of Parks and Historic Preservation.](#)
 - [Routine monitoring of sediment quality at 25 fixed sites, on a five year rotating basis \(five sites monitored annually, and 10 discretionary sites annually. All sites are monitored for several heavy metals and organic contaminants. A pore water sample is analyzed for ammonia and a Microtox toxicity test on the pore water is performed.](#)

2. Intensive Surveys

- A. Objective: To characterize the water quality impacts from a specific pollutant source area.
- B. Design Methodology: Determination of contaminants of concern based on previous water quality studies, effluent sampling and or NPDES permit applications, use of multiple sampling stations downstream and upstream (if appropriate). If contaminants of concern have significant seasonal or daily variation, season of the year and time of day variation must be accounted for in sampling design. These studies would also require multiple samples per site over a relatively short time frame (e.g., 6-8 visits over a 2-3 day period or 10-15 visits over a 2-3 year period).
- C. Number of Sites, Sampling Methods, Sampling Frequency, Parameters:
- Missouri DNR conducts or contracts for 4-6 special studies annually. Each study would have multiple sampling sites. Number of sites, sampling frequency and parameters would all vary greatly depending on the study. [By 2000, staff increases in the Water Pollution Control Program and the Environmental Services Program staff should allow for 10-15 such studies annually.](#)

3. Toxics Monitoring Program

Monitoring of toxics is not a separable part of the monitoring program. The fixed station network and many of our intensive studies monitor for toxic chemicals. In addition, major municipal and industrial dischargers must monitor for toxicity in their effluents as a condition of their NPDES permits.

4. Biological Monitoring Program

- A. Objective: To develop numeric criteria describing “reference” aquatic macroinvertebrate communities in Missouri’s wadeable streams. To implement these criteria within state water quality standards and begin a state-wide aquatic invertebrate monitoring program in 2001 as part of a DNR/MDC cooperative state-wide biological monitoring program. This program would sample fish and benthic macroinvertebrates in at least 50 stream locations annually. The network would include long term fixed station sites, sites believed to be impaired by specific point or nonpoint stressors and randomly selected sites.
- B. Design Methodology: Development of Biocriteria for Invertebrates involves identification of 45 “reference” streams divided among Missouri’s three aquatic ecoregions. Intensive sampling of invertebrate communities to quantify temporal and spatial variation in reference streams within ecoregions and variation between ecoregions. Sampling of chemically and physically impaired streams to test sensitivity of various community metrics to differences in stream quality.

The state-wide biological monitoring program which will begin in 2001 will run on a three year cycle. Each year at least 50 sites will be monitored for fish and aquatic macroinvertebrates. Some water chemistry sampling and a physical habitat assessment will be done at each site. Two thirds of the work done in a cycle will be monitoring of a combination of fixed stream sites and sites of special interest (those suspected of being impaired by point or nonpoint stressors such as streams on the state 303d list). The remaining third of this sampling effort in each cycle will consist of randomly selected stream sites that should assist in making probability-based statements about biological condition in Missouri streams generally.

- C. Number of Sites, Sampling Methods, Sampling Frequency, Parameters:

Biocriteria Development for Aquatic Invertebrates 1991-2000: 45 reference sites, 40 other sites with varying degrees of physical or chemical impairment, modified EPA Rapid Bioassessment Protocol for Invertebrates Sites have been sampled 2-6 times over the last nine years for aquatic invertebrates, temperature, dissolved oxygen, specific conductance and nutrient ions.

Biomonitoring Network (beginning 2001): at least 50 sites annually. Fish communities will be sampled once, aquatic invertebrates twice (spring and fall) annually. Aquatic invertebrate monitoring will follow protocols established during the biocriteria development process. The Dept. of Conservation has initiated a pilot fish sampling study in 1999 that will result in codification of fish sampling protocols by 2001.

5. Fish Tissue

- A. Objective: Measure levels of bioaccumulative toxicants in fish.
- B. Design Methodology. Sites were chosen based on one of the following criteria:
- site is believed to have water and sediment quality representative of many neighboring streams of similar size due to similarity in geology, hydrology and land use, and the absence of any known impact from a local point source or discrete nonpoint water pollution source.
 - site is downstream of a significant point source or localized nonpoint source area.
- C. Number of Sites, Sampling Methods, Sampling Frequency, Parameters:
- 15 sites, fish taken by electroshocking, ideally a sample is composed of five whole carp *Cyprinus carpio* of equal size (fish of approximately 18" length are preferred). Sites are sampled once every two years and are analyzed for several chlorinated hydrocarbon insecticides, PCBs, lead, cadmium, mercury and fat content.

Laboratory Analytical Support

1. Laboratories Used:

- USGS/DNR Cooperative Fixed Station Network: USGS Lab, Denver, Colorado
- Crowder College Network: Crowder College, Neosho, Missouri
- DNR Public Drinking Water Reservoir Network: Missouri DNR Environmental Lab
- Intensive Surveys: Varies, many are done by Missouri DNR Environmental Lab
- Toxicity Testing of Effluents: many commercial labs
- Biological Criteria for Aquatic Invertebrates: Missouri DNR Environmental Lab and University of Missouri, Columbia
- Fish Tissue: USEPA Region VII Lab, Kansas City, Kansas and Miscellaneous contract labs (Missouri Department of Conservation)
- NPDES self-monitoring: commercial labs
- DNR Public Drinking Water Monitoring: Missouri DNR and commercial labs
- Agricultural Research Service: ARS lab

2. Issues:

USGS, Denver, Colorado. (1) previously and for several years had used inadequate reagent volumes in Total Phosphorus analysis. Lab has published paper on the situations where erroneous data was believed to occur. Problem was associated with high levels of phosphorus usually only encountered in certain effluents and should not have caused an error in analysis of phosphorus in Missouri streams. (2) USGS has recommended new “clean procedures” for making accurate measurements of certain heavy metals. Because of the great expense of using these new methods, the USGS/DNR coop network continues to use the old methods. The rationale for this decision was that the old method is still reliable enough to discern any exceedences in water quality standards, but may not be of value in correlating heavy metals to water quality or other environmental variables and probably will not allow time trend analysis on most waters of the state.

Quality Assurance/Quality Control Program (QA/QC)

Missouri and Region VII EPA have completed a Total Quality Management Plan. All environmental data generated directly by the department or through contracts funded by the department or EPA will require a quality assurance project plan (QAPP) following the QAR5 guidance.

Data Storage, Management and Sharing

The department retrieves raw data from the U.S. EPA database, STORET, from the USGS database, WATSTORE and from numerous state, federal and municipal sources that do not store data in WATSTORE or STORET. This data is imported into the Missouri state computer system for storage and statistical analysis. The department maintains some water chemistry data in SPFPC files at the state computer center in Jefferson City. Data in these files comes from WATSTORE, STORET and data generated by state agencies and large municipalities and public water supply companies. [These files are retrieved, manipulated and statistically analyzed by SAS software. During 2000, DNR will be training at least one person in data entry and retrieval in the new version of STORET.](#)

Other special files such as volunteer monitoring water quality data, herbicide levels in surface waters or ground waters, levels of pesticides in fish tissue or results of toxicity testing of effluents and receiving waters are maintained in SPFPC or DBASE files within the department’s Water Pollution Control Program. Data on permitted waste water treatment facilities state-wide, including results of effluent monitoring and an assessment of the water quality impacts of these facilities, is maintained at the state computer center in the Water Quality Information System (WQIS). [Beginning in 1999, DNR has begun linking many separate data bases pertaining to water quality, other environmental data and information on regulated facilities via ACCESS software and import this data into a GIS environment. This work should be largely completed in 2000.](#)

The Missouri Department of Conservation is in the process of developing statewide databases for both fish and aquatic macroinvertebrates.

Training and Support of Volunteer Monitoring

Two volunteer monitoring programs are now generating water quality data in Missouri. The first is a cooperative program between the Department of Natural Resources, the University of Missouri and volunteers that monitor approximately 16 lakes, including Lake Taneycomo, Table Rock Lake and several lakes in the Kansas City area. Data from this program is used by the University as part of a long-term study on the limnology of Midwestern reservoirs.

The second program monitors water quality of streams throughout Missouri. It is a cooperative project of the Department of Natural Resources, the Department of Conservation and the Conservation Federation of Missouri. By the end of 1997, this program had provided initial training, equipment and supplies to about 971 volunteers, provided secondary training and quality assurance-quality control ratings for 153 members of this group and established a data base for all data reported by the volunteers. In 1998-99 an additional 831 persons had received training. The program now has 321 people who have a Level 2 or higher data quality assurance rating. This rating allows any data they provide to be used in the department's water quality assessment database. During the period 1997 through 1999, level 2 or higher rated volunteers submitted at least three sets of aquatic invertebrate data at 69 stream sites and at least three sets of chemical data on 105 stream sites.

Data Interpretation and Communication

Missouri now uses the EPA original version of the ACCESS database for tracking and reporting waterbody use attainment information. An EPA contractor, RTI, completed geo-referencing of Missouri's classified waters in 1998. This work will allow other files to be imported into a GIS environment and linked to specific stream segments or lakes. During the next two years WPCP plans to link many of our databases on permitted facilities and environmental data and access them within a GIS environment. Much of this information should become available over the WPCP website.

Water quality data accessibility is easy. Contact the Water Pollution Control Program for more information:

1. Requests for very general information on water quality. These requests are filled by the 305(b) report, pamphlets or fact sheets. Call 1-800-361-4827. Information on Missouri's 303(d) list and completed Total Maximum Daily Load (TMDL) studies are available on the Internet at:

<http://www.dnr.state.mo.us/wpcp/homewpcp.htm>
2. Requests for information on a specific waterbody or for more detailed information on a specific topic that might include summaries of major studies or summary of available data. These requests are usually filled by the Missouri Basin Plans, a document that describes Missouri's 77 basins and provides information on land use, hydrogeology, stream flow and water quality in each.
3. Requests for published reports or water quality data files. If the report or data was generated by the department, it can be obtained either through the mail (paper copy for small reports and data files or on floppy disk for larger data files) or by visiting the department office at 205 Jefferson Street in Jefferson City and viewing the files directly. If the report or data file did not originate with the department, the request is sent to the organization that published the report/data.

Requests for water quality information or requests to view water quality data files should be sent to:

Missouri Department of Natural Resources
Water Pollution Control Program
ATTN: John Ford
P.O. Box 176
Jefferson City, MO 65102-0176
Phone: (573) 751-7024 Fax: (573) 526-5797
Internet: nrfordj@mail.dnr.state.mo.us

Monitoring Program Evaluation

The water quality monitoring program within the department has traditionally focused on the chemical characterization of water quality in streams both free of and those subject to point source waste water discharges. While the monitoring has been able to keep pace with our more critical point source assessment needs and has done a good job of characterizing regional water quality unimpaired by point source discharges, the size and scope of the department's monitoring has fallen far short of the state's information needs. [The advent of large confined animal feeding operations \(CAFOs\) in Missouri, concern over eutrophication of our large recreational lakes and continuing urban sprawl, among other problems, have spawned questions our present monitoring program was incapable of answering.](#)

Significant steps toward meeting these monitoring needs were made by DNR in 1999. These included:

- 1) Increasing biological monitoring staff from its present 2.5 FTEs to 6 FTEs in 2000.
- 2) Increasing other water quality monitoring staff from its present 2.5 FTEs to 4.5 FTEs in 2000.
- 3) Increasing water data management staff from its present 0.5 FTE to 2.5 FTE in 2000.
- 4) Increases in our budget for contracting water quality monitoring by others. This has allowed us to add 27 stations to our fixed station chemical monitoring network in 1999. We are now monitoring 63 sites throughout the state.
- 5) Signing a Memorandum of Understanding with the Department of Conservation to initiate a comprehensive state-wide aquatic biological monitoring program beginning in 2001

PLAN FOR ACHIEVING COMPREHENSIVE ASSESSMENTS

Large Rivers

1. Fixed Station Water Quality Monitoring Network. The department's objective is to maintain a minimum of 15 fixed sites dedicated to long term chemical monitoring of large rivers. These sites will be monitored 6-12 times annually for a long list of conventional contaminants, major ions, nutrient ions, heavy metals. Some of the stations will also have pesticide monitoring. These sites will be chosen as those most representative of the physiographic province they are in and ones with the largest existing water quality record. [Missouri DNR through a cooperative agreement with the US Geological Survey now monitors 31 such sites.](#)
2. Sediment Monitoring Network. The department's objective is to maintain a minimum of 15 fixed sites where sediments will be monitored at least once every five years. The department's present sediment monitoring program includes a 25 site fixed station network on 17 large rivers with each site being monitored every five years. An additional 10 sites per year are monitored to address known or suspected sediment pollution problems or are sites selected randomly to allow probability based assessment of sediment quality state-wide.. The program analyzes for bulk sediment chemistry, sediment pore water chemistry and pore water toxicity. These additional site may or may not be on large rivers.
3. Monitoring Programs for the Mississippi and Missouri Rivers. Very large rivers require special monitoring efforts for several reasons. Among these are 1) the fact that they are unique aquatic ecosystems with specialized habitats and fauna not found in smaller rivers, 2) due to their size, depth and current velocity, they are often difficult to monitor and historically have been studied less effectively than smaller streams 3) they tend to attract types of human uses and accompanying environmental stresses (specifically commercial navigation) not found on smaller streams.

[The monitoring concepts embraced by the Long Term Monitoring Program on the Upper Mississippi River are wide ranging. They involve description of physical, chemical and biological aspects of the river and environs with an eye toward synthesis describing its function as an ecosystem. Missouri supports this approach and supports the development of a similar monitoring project on the Missouri River. In addition to these activities, Missouri has fixed station chemical monitoring at two locations on the Missouri and two on the Mississippi. DNR also regularly reviews water quality data on these two rivers from other state, federal and municipal sources.](#)

Discussion: The water and sediment monitoring locations will be chosen so that rivers from all physiographic provinces and predominant land use categories are represented. Thus most unmonitored larger rivers in the state can be “evaluated” based on monitored representative streams from areas of similar geology, hydrology and land use. As land use patterns change, [water quality](#) may become unlike nearby rivers. If this occurs in the watershed of a monitored river, it can no longer be considered representative of other rivers within that physiographic province. If these changes occur in an unmonitored river, that river would become a high priority monitoring location since other rivers in the province would not be considered adequate indicators of water quality in this stream..

This situation has already occurred in the Elk River basin, where many large poultry operations are now located. Several years ago, the fixed water quality monitoring station on the Elk at Tiff City was monitored only every second or third year as a station representative of southwestern Missouri. It is now monitored annually, not as a representative stream for rural southwest Missouri, but as a stream draining a basin with a large amount of poultry production.

Wadeable Streams (Small Rivers and Creeks)

1. Visual/Qualitative Aquatic Invertebrate Rapid Stream Assessment. A protocol for rapid stream assessment was developed and implemented by the department in 1982 and has been practiced unchanged since that time. The goal of the rapid stream assessment program is to make an assessment of the impact of all municipal wastewater discharges, limestone quarries, clay pits and landfills at least once every five years. A second objective is to assess non-municipal wastewater discharges on an as needed basis based on regional office inspection reports, [complaints by the public or other agencies or based on Level One volunteer water quality monitoring results](#).

[Due to the 1999 DNR water quality monitoring expansion, the present 0.15 FTE dedicated to this type of monitoring will be increased to 0.6 FTE in 2000. This expansion is expected to allow us to conduct 300 of these surveys annually, an amount that would be approximately 150% of our expected demand for this type of monitoring..](#)

2. Volunteer Water Quality Monitoring. Data collected by volunteers who successfully complete a quality assurance workshop is entered into the department’s water quality databases and is used by the department in the same way as the visual/qualitative benthic data collected by the department. Some volunteers are doing only chemical monitoring but many are also doing semi-quantitative macroinvertebrate benthic sampling. By the end of 1999, volunteers with acceptable quality assurance ratings were monitoring and reporting to the department on [69](#) stream sites regularly for aquatic invertebrates and [105](#) stream sites for water chemistry. [We anticipate the number of sites monitored by volunteers to increase in the future since this program continues to grow.](#)
3. Aquatic Macroinvertebrate/Fish/Aquatic Habitat Monitoring Program. By 2002, the department will conducting aquatic invertebrate monitoring program involving at least 50 stream sites annually and will have 6 FTE dedicated to aquatic invertebrate monitoring. A Memorandum of Understanding with the Department of Conservation (MDC) will complement the DNR invertebrate monitoring program by merging it with a new state-wide fish community monitoring program by MDC. As part of this agreement, the two departments will agree upon and begin using a single habitat monitoring protocol beginning in 2004. This monitoring program will sample 1) selected long term fixed sites, 2) sites which may be impaired by specific point or nonpoint sources and 3) sites selected randomly to allow probability based statements about aquatic biotic communities state-wide.

4. Intensive Surveys. There is a great variety of water quality monitoring efforts generally referred to as “intensive surveys.” They have in common only the fact that they are efforts that are aimed at answering a specific question on a specific waterbody or group of waterbodies. Examples would include 1) wasteload allocation studies which result in determining acceptable effluent loads from point source discharges; 2) total maximum daily load studies which determine acceptable contaminant loads from the entire watershed; 3) less intensive studies [to generally characterize water quality impacts](#) of specific point or discrete nonpoint source discharges; 4) monitoring in support of Section 319 watershed projects; and 5) a number of other studies relating to effluent quality, surface or ground water quality or hydrology or studies of the aquatic biota.

To meet our commitment to maintain our proposed TMDL study schedule and other water quality management functions, DNR will need to have the capacity to conduct 15-20 such intensive surveys annually. With significant expansion in DNR monitoring activities in 2000 our ability to perform these surveys has increased from about 6 annually in 1999 to about 10-15 annually now. This is only a marginally acceptable figure and in terms of our program objectives.

Lakes

1. Lake Monitoring Network. Approximately 110 Missouri lakes are monitored quarterly for nutrients, chlorophyll, secchi depth and solids by the University of Missouri under a cooperative program with Missouri DNR. This project has been ongoing for several years and has characterized the trophic states of these lakes and has laid the foundation for a basic understanding of the relationship of nutrients, mineral solids and algal productivity in midwestern reservoirs.
2. Lakes of Missouri Volunteer Monitoring Program. This program has recruited over 70 volunteers to collect water samples and make field observations. Eleven reservoirs in Missouri were monitored by this program in 1997. [DNR believes that volunteer interest and support of lake monitoring far exceeds our present utilization of volunteers. In 2000, DNR and the University of Missouri will explore ways to expand the present lake volunteer program.](#)

[Use of Data Generated by Others](#)

1. [DNR has and will continue to actively solicit, import into our databases, analyze and otherwise use any and all water quality data with an acceptable level of quality assurance.](#)

ASSESSMENT METHODOLOGY

This section describes the procedures used by the Missouri Department of Natural Resources to rate the quality of Missouri’s waters.

Water quality is judged by its conformance with Missouri’s Water Quality Standards. These standards were first implemented for all Missouri streams and a few large lakes in 1970 and are revised every three years. These standards now list over 22,000 miles of classified streams and 415 significant public lakes representing 293,000 surface acres of water, and the uses for which these waters are protected. These standards also list the maximum allowable concentrations of chemicals and bacteria in these waters.

The table below lists the various uses of Missouri’s waters and the portions of state waters that are protected for each use.

TABLE 5. MISSOURI WATERS PROTECTED FOR VARIOUS USES

<u>Use</u>	<u>Stream Miles</u>	<u>% of Total</u>	<u>Lake Acres</u>	<u>% of Total</u>
Protection of Aquatic Life and Fish Consumption	22,065.4	100	293,305	100
Subset: Warm-Water Fishery	19,080.2	86	282,575	96
Cool-Water Fishery*	2,756.7	13	0	0
Cold-Water Fishery**	228.5	1	10,730	4
Livestock and Wildlife Watering	22,065.4	100	293,305	100
Whole-Body-Contact Recreation	5,428.9	25	262,459	89
Boating	6,953.7	32	234,990	80
Drinking Water Supply	3,235.7	15	100,283	34
Industrial	1,588.5	7	7,003	2
Non-degradation: Outstanding National	171.2			
State Resource Waters	192.5***			
Irrigation	4,025.5	18	0	0
Total Classified Waters in Missouri	22,065.4		293,305	

* Smallmouth Bass, Rock Bass

** Trout

*** Outstanding State Resource Waters also include 270 acres of marsh in 3 locations.

Classified waters of Missouri are all permanently flowing streams or streams with permanent pools. All classified waters of the state and all significant public lakes are classified for protection of aquatic life, livestock and wildlife watering and fish consumption by humans. The Water Quality Standards for these uses set the maximum allowable concentrations for 110 chemicals in these waters. A subset of these waters classified for drinking water supply have maximum allowable concentrations for an additional 20 chemicals in the Standards. Waters protected for whole-body-contact recreation such as swimming or water skiing also have a maximum allowable bacteria standard.

Missouri's Water Quality Standards also contain narrative criteria. These standards are not numbers but general statements about the department's expectations for waters of the state. These standards require waters to be free of objectional odors, color, turbidity, floating materials or bottom deposits and to be free of conditions harmful to aquatic life such as high water temperature, low dissolved oxygen or chemical toxicity. Importantly, these standards apply not just to the classified waters, but to all waters of the state including the small intermittent streams that only carry water during and shortly after rain or snow melt.

Table 6 below shows how the chemical and bacterial standards and aquatic biological information are used to rate the quality of Missouri's waters.

TABLE 6. METHODS FOR ASSESSING COMPLIANCE WITH
WATER QUALITY STANDARDS

BENEFICIAL USES	DATA TYPE	DATA QUALITY CODE*	COMPLIANCE WITH WATER QUALITY STANDARDS
Overall use protection	No data-- evaluated based on similar land use/ geology as stream with water quality data.		Given same rating as monitored stream with same land use and geology.
	Visual observation of	1	<u>Full</u> : Stream appearance and aquatic invertebrates

BENEFICIAL USES	DATA TYPE	DATA QUALITY CODE*	COMPLIANCE WITH WATER QUALITY STANDARDS
	stream and qualitative evaluation of aquatic macroinvertebrates.		typical of reference streams in this region of the state. <u>Partial</u> : Odor, turbidity, objectionable, suspended matter or bottom deposits that would interfere with beneficial uses or reduced diversity of aquatic macroinvertebrates. <u>Non-Attainment</u> : Odor, turbidity, or objectionable suspended matter bottom deposits severe enough to prohibit beneficial use or only pollution tolerant aquatic invertebrates found.
Protection of Aquatic Life	Chemical (toxics)	1-2	<u>Full</u> : No more than 1 exceedence of acute criterion in 3 years; less than 10% of all samples exceed chronic criterion. <u>Partial</u> : More than 1 exceedence of acute criterion in 3 years; less than 10% of all samples exceed chronic criterion. <u>Non-Attainment</u> : More than 10% of all samples exceed chronic criterion.
	Chemical (conventional)	1-2	<u>Full</u> : Less than 10% of all samples exceed criterion. <u>Partial</u> : 10-25% of all samples exceed criterion. <u>Non-Attainment</u> : More than 25% of all samples exceed criterion.
	Biological	3	<u>Full</u> : Fauna very similar to regional reference streams. <u>Partial</u> : Diversity or number of intolerant taxa slightly to moderately less than reference streams. <u>Non-Attainment</u> : Diversity or number of intolerant taxa much less than reference stream.
	Toxicity testing of effluent	2	<u>Full</u> : No statistically significant mortality in either of two tests species at the AEC*** or the AEC must be less than 30% of the LC ₅₀ ** for both test species. <u>Non-Attainment</u> : Conditions for full attainment not met.
	Toxicity testing of streams or lakes	3	<u>Full</u> : No statistically significant deviation from controls in chronic test endpoints in at least two representative species. <u>Non-Attainment</u> : Statistically significant mortality in at least one of two representative test species.
Fish Consumption	Chemicals (water) Chemicals (tissue)	1-2	<u>Full</u> : Water quality criteria not exceeded as a long-term average; fish consumption advisories allow typical or average fish consumption rates for all commonly eaten species. <u>Partial</u> : Fish consumption advisories allow less than typical or average consumption rate for at least one commonly eaten species. <u>Non-Attainment</u> : Water quality criteria exceeded as long-term average or consumption banned for at

BENEFICIAL USES	DATA TYPE	DATA QUALITY CODE*	COMPLIANCE WITH WATER QUALITY STANDARDS
			least one commonly eaten species.
Drinking Water Supply	Physical, chemical (nutrients)	1-2	<p><u>Full</u>: Very little loss of lake volume due to sedimentation, low levels of nutrients, no history of taste or odor problems due to algae.</p> <p><u>Threatened</u>: Rate of sedimentation moderate and no taste and odor problems known but nutrient or algae levels similar to lakes with taste and odor problems.</p> <p><u>Partial</u>: Water supply may be inadequate in dry years due to loss of volume to sedimentation or supply has infrequent taste and odor problems.</p> <p><u>Non-Attainment</u>: Water supply has chronic water shortage due to loss of storage volume to sedimentation or frequent taste and odor problems or supply causes infrequent gastrointestinal problems in users.</p>
	Chemical (toxics, raw water)	1-2	<p><u>Full</u>: Mean values do not exceed criterion or Safe Drinking Water Act (SDWA) maximum contaminant levels (MCLs).</p> <p><u>Threatened</u>: Chemical use patterns in watershed are similar to watersheds with non-attainment.</p> <p><u>Non-Attainment</u>: One or more contaminants have mean values in excess of water quality criteria or SDWA MCLs.</p>
	Chemical (Iron, Manganese, Total Dissolved Solids, Raw Water)	1-2	<p><u>Full</u>: Mean values do not exceed criterion.</p> <p><u>Threatened</u>: Mean values do not exceed criterion but time trends suggest mean may be exceeded in future.</p> <p><u>Non-Attainment</u>: Mean values exceed criterion.</p>
	Chemical (toxics, finished water)	1-2	<p><u>Full</u>: No MCLs or Water Quality Standards criteria exceeded or significant taste and odor problems using only convention treatment (sedimentation-disinfection).</p> <p><u>Threatened</u>: Chemical use patterns in watershed are similar to watersheds not in full attainment.</p> <p><u>Partial</u>: Additional treatment needed to meet MCLs or Water Quality Standards criterion.</p> <p><u>Non-Attainment</u>: At least one contaminant has annual average exceeding MCL or Water Quality Standards criterion or supply has been closed during the past 2 years due to contamination of raw water entering the plant.</p> <p>NOTE: water quality problems caused by the drinking water treatment process such as the formation of Trihalomethanes (THMs) are not included.</p>
Whole-Body-	Fecal Coliform count	1-2	<u>Full</u> : Water Quality Standards not exceeded as a

BENEFICIAL USES	DATA TYPE	DATA QUALITY CODE*	COMPLIANCE WITH WATER QUALITY STANDARDS
Contact Recreation			geometric mean for samples collected during the recreation season and at times not influenced by storm water flows. <u>Non-Attainment</u> : Geometric mean does exceed Water Quality Standard criterion during recreation season at times not influenced by storm water flows.
Irrigation, Livestock and Wildlife Water	Chemical (boron, cobalt)	1-2	<u>Full</u> : Mean value does not exceed water quality criteria. <u>Non-Attainment</u> : Mean value does exceed water quality criteria.

* Data quality codes have been established by EPA to rate the quality and quantity of data from a specific source. Level one data is the lowest level of useable data and includes infrequent chemical monitoring or qualitative biological monitoring. Level Two data would include intensive water chemistry studies, long-term water chemistry monitoring sites and fish tissue analysis. Levels Three and Four are for detailed biological studies of fish, aquatic invertebrates and toxicity testing of waters.

** LC₅₀ The concentration of a contaminant that kills 50% of test organisms.

*** AEC = Acceptable Effluent Concentration. This is the percentage of effluent in a solution of effluent at the effluent design (max.) Flow mixed with 2.5% of the 7Q₁₀ low flow of the receiving stream. This would simulate the instream toxicity potential of the discharge during dry weather.

WATER QUALITY ASSESSMENT

Table 7. Summary of Fully Supporting, Threatened and Impaired Waters

Degree of Use Support	Evaluated Streams Miles	Monitored Streams Miles	Total Stream Miles Assessed	Evaluated Lake Acres	Monitored Lake Acres	Total Lake Acres Assessed
Fully Supporting All Assessed Uses	8,287.0	2,842.5	11,129.5	15,676	94,513	110,189
Full Supporting All Assessed Uses, But Threatened For at Least One Use	65.5	98.7	164.2	10,192	112,049	122,241
Impaired For One or More Uses	6,960.6	3,360.8	10,321.4	0	60,875	60,875
TOTAL ASSESSED	15,313.1	6,302.0	21,615.1	25,868	267,437	293,305
TOTAL UNASSESSED			450.8			0

Monitored waters are those where water quality data has been collected in the last 5 years. 28.5% of all classified stream miles and 91.1% of all classified lake acres were considered to be monitored

Evaluated waters are those which have not been monitored in the last 5 years but have geology and land use similar to nearby monitored waters and whose water quality assessment is assumed to be the same as those nearby monitored waters. 69.1% of all classified stream miles and 8.8% of all classified lake acres were considered to be evaluated.

Unassessed waters are those that are not monitored directly nor do they have nearby monitored waters with similar geology and land use. Thus, these represent the classified waters in the state for which we are unable to make an accurate assessment of their compliance with water quality standards and Clean Water Act goals. 2.3% of classified stream miles fall into this category. No classified lake acres are considered to be unassessed.

IMPAIRED WATERS AND OTHER AREAS OF CONCERN

ADDITIONAL INFORMATION ON MISSOURI LAKES

Summary Statistics

Information on beneficial use attainment in significant public lakes is given in Tables 1 and 1A. The acreage of these lakes not fully supporting beneficial uses by major source category are as follows:

Point Sources	14,000 acres
Nonpoint Sources	34,491 acres
Hydromodification	116,85 acres

Background

Missouri's definition of "significant" lakes corresponds to the Department of Natural Resources list of classified lakes and includes any lake that falls into one of the following three categories: (1) small public drinking water reservoirs; (2) large multi-purpose reservoirs; and (3) reservoirs or lakes with important recreational values.

It should be noted that Missouri has only a few naturally occurring lakes, [these](#) being [primarily](#) depressions or old ox-bows on the Missouri or Mississippi river floodplain. Most significant "lakes" in the state are man-made reservoirs.

Trophic Status

Eutrophication is a natural process that occurs in lakes involving the gradual filling of the lake over time accompanied by increasing aquatic plant growth. This concept also explains the enrichment of lakes and reservoirs by additions of nitrogen and phosphorus from human activity. This additional nutrient load causes increased aquatic plant growth, predominantly phytoplankton, which causes lake water to become greener and more turbid. Trophic state is an important way to characterize lakes because it relates directly to such factors as lake clarity, better in oligotrophic and mesotrophic lakes, and fish production, better in eutrophic lakes.

The trophic status of lakes typically refers to the amount of nitrogen and phosphorus entering the lake or the amount of algae or other aquatic plants present in the lake. Oligotrophic lakes are clear with few nutrients and very little aquatic plant growth. Mesotrophic, eutrophic and hypereutrophic refer respectively to lakes with increasing levels of nutrients and aquatic plant growth.

Lake studies conducted by the University of Missouri between 1989 and 1996 on trophic status of Missouri lakes follows.

TABLE 8. TROPHIC STATUS OF SELECTED MISSOURI RESERVOIRS

<u>LAKE</u>	<u>COUNTY</u>	<u>LOCATION</u>	<u>SECCHI</u>	<u>TP</u> ¹	<u>Ch1-a</u> ²	<u>TROPHIC</u> ³ <u>STATE</u>	<u>TN</u> ⁴
<u>GLACIAL PLAINS</u>							
*Allaman Lake	Clinton	24, 56N, 30W	1.2	42	16	E	683
Baring C-Club Lake	Knox	26, 63N, 12W	1.3	28	21	E	959
Bean Lake	Platte	12-14,54N,37W	0.1	264	144	HE	1,658
Bethany Lake	Harrison	27, 64N, 28W	1.1	36	12	E	760
Big Lake	Holt	18-19,61N,39W	0.2	328	166	HE	2,508
Blind Pony Lake	Saline	SE18,49N,22W	0.7	79	42	E	1,190
Bowling Green Lake	Pike	29, 53N, 2W	1.7	29	11	E	574
Brookfield Lake	Linn	33, 58N, 19W	1.1	25	9	M	668
Concordia Lake	Lafayette	20, 48N, 24W	0.6	85	25	E	1,136
D.C. Rogers Lake	Howard	3, 50N, 16W	1.3	31	7	M	533
Daniel Boone Lake	Shelby		0.2	192	37	E	1340
Dean Lake			0.1	382	5	HE	2,110
Deer Ridge Lake	Lewis	18, 62N, 8W	0.8	52	17	E	810
Edina Reservoir	Knox	12, 62N, 12W	0.7	71	20	E	1,228
Ella Ewing Lake	Lewis	21, 64N 10W	0.6	87	28	E	1,410
Fayette Lake #2	Howard	4, 50N, 16W	0.9	52	24	E	906
Forest Lake	Adair	14, 62N, 16W	1.4	26	5	M	436
Green City Lake	Sullivan	NE16,63N,18W	0.7	91	33	E	1,123
Hamilton Lake	Caldwell	15, 57N, 28W	0.8	66	14	E	1,002
Hazel Creek Lake	Adair	31, 64N, 15W	1.5	29	8	M	630
Henry Sever Lake	Knox	14, 60N, 10W	1.0	47	24	E	916
Hunnewell Lake	Shelby	25, 57N, 9W	0.8	50	24	E	847
King Lake	Gentry	SW34,61N,32W	0.2	252	12	E	1,690
Kings Lake	Lincoln	25,50N,2E	0.3	278	80	HE	1,573
Lake Contrary	Buchanan	26, 57N, 36W	0.3	365	194	HE	3,060
Lake Mahoney (Unionville)	Putnam	27, 66N, 19W	0.6	105	39	E	1,266
Lake Marie	Mercer	36, 66N, 24W	2.7	15	4	M	445
Lake Paho	Mercer	25, 65N, 25W	0.8	47	13	E	865
Lake Viking	Daviess	9, 59N, 28W	1.3	29	11	E	563
Little Dixie Lake	Callaway	26, 48N, 11W	0.6	75	16	E	810
Long Branch Lake	Macon	18, 57N, 14W	0.7	52	14	E	873
Macon Lake	Macon	17, 57N, 14W	0.8	55	27	E	876
Marceline Res.	Linn	28, 57N, 18W	0.7	114	48	E	1,147
Mark Twain Res. (Lower)	Ralls	26, 55N, 7W	1.1	77	18	E	1,364
Mark Twain Res. (Upper)	Monroe			101	16	E	1,220
Maysville Lake (NW)	Dekalb	33, 59N, 31W	0.6	204	46	E	1,286
Memphis Lake #2	Scotland	15, 65N, 12W	0.6	69	37	E	1,177
Milan Lake (New)	Sullivan	35, 63N, 20W	1.0	43	14	E	689
Monroe City Lake B	Monroe	30, 56N, 7W	0.5	83	30	E	1,135
Nehai Tonkayea Lake	Chariton	11, 55N, 18W	1.6	19	3	M	431
Pony Express Lake	Dekalb	33, 58N, 31W	0.8	69	32	E	1,075
Prairie Slough (Oxbow)			0.2	231	72	HE	2,495
Rocky Fork Lake	Boone	31, 50N, 12W	1.9	23	7	M	546
Shelbina Lake	Shelby	20, 57N, 10W	0.6	100	37	E	1,081
Smithville Lake	Clay	13, 53N, 33W	1.1	35	15	E	788
Spring Lake	Adair	SW20,61N,16W	1.2	35	9	M	533

LAKE	COUNTY	LOCATION	SECCHI	TP ¹	Ch1-a ²	TROPIC ³	
						STATE	TN ⁴
Sterling Price Lake	Chariton	17,53N,17W	0.6	108	83	HE	1,545
Sugar Creek Lake (MOB)	Randolph	16, 54N, 14W	0.8	56	26	E	765
Sugar Lake	Buchanan	27 55N, 37W	0.2	333	173	HE	2,524
Swan Pond			0.3	345	126	HE	1,658
Thomas Hill Res.	Randolph	24, 55N, 16W	0.7	49	16	E	795
Thunderhead Lake	Putnam	15, 66N, 19W	0.8	52	13	E	977
*Tri-City Comm Lake	Boone	24, 51N, 12W	0.7	58	20	E	876
Vandalia Lake	Pike	12, 53N, 5W	1.2	63	34	E	897
Wakonda Lake	Lewis	NE13, 60N, 6W	0.8	95	51	E	1,186
Watkins Mill Lake	Clay	22, 53N, 30W	0.9	43	16	E	624
Waukomis Lake	Platte	17, 51N, 33W	1.7	25	14	E	590
Williams Lake (Rcky Holl)	Clay	33, 53N, 30W	1.4	55	21	E	784
<u>OSAGE PLAINS</u>							
Amarugia Highlands Lake	Cass	10,43N,32W	0.7	63	13	E	755
Atkinson Lake	St. Clair	6, 37N, 28W	0.6	77	35	E	940
Blue Springs Lake	Jackson	3, 48N, 31W	1.0	36	16	E	553
Bushwacker Lake	Vernon	27,34N,32W	1.6	28	16	E	605
Cat Claw Lake	Jackson	14,47N,31W	0.2	126	4	E	862
Coot Lake	Jackson	22,47N,31W	0.6	50	10	E	856
Cottontail Lake	Jackson	14,47N,31W	0.2	140	15	E	946
Four Rivers CA	Bates	,T38N,R30W	1.0	34	7	M	460
Gopher Lake	Jackson	23,47N,31W	0.4	94	17	E	776
Harmony Mission Lake	Bates	15,38N32W	1.5	44	20	E	789
Harrisonville Lake	Cass	26, 46N, 31W	0.9	50	16	E	946
Higginsville Lake	Lafayette	9, 49N, 25W	0.7	106	21	E	1,251
Holden City Lake	Johnson	7,45N,27W	0.8	43	16	E	992
H.S. Truman Lake	Benton	7, 40N, 23W	1.1	44	15	E	951
Jackrabbitt Lake	Jackson	15,47N,31W	0.2	168	14	E	783
Lake Jacomo	Jackson	11, 48N, 31W	1.3	34	19	E	573
Lake Tapawingo	Jackson	34, 49N, 31W	1.2	34	32	E	842
Lamar Lake	Barton	32, 32N, 30W	0.8	78	42	E	945
Longview Lake	Jackson	20, 47N, 32W	0.8	38	12	E	757
Lotawana Lake	Jackson	29, 48N, 30W	1.4	31	16	E	672
Maple Leaf Lake	Lafayette	04,48N,26W	1.1	46	24	E	938
Montrose Lake	Henry	33, 41N, 27W	0.2	189	63	HE	1,292
Nell Lake	Jackson	15,47N,31W	0.6	68	12	E	834
North Lake	Cass	28, 45N, 31W	0.7	91	38	E	987
Prairie Lee Lake	Jackson	27, 48N, 31W	0.8	55	25	E	915
Raintree Lake	Cass	6, 46N, 31W	0.6	56	18	E	1,005
Spring Fork Lake	Pettis	21, 44N, 21W	0.6	142	43	E	1,118
*Tebo Lake	Pettis	12, 44N, 22W	2.8	18	4	M	609
(Westmoreland)							
Winnebago Lake	Cass	9, 46N, 31W	0.9	53	18	E	875
<u>OZARK BORDER</u>							
Binder Lake	Cole	36, 45N, 13W	1.1	50	18	E	740
Creve Couer Lake	St Louis	20, 46N, 5E	0.3	154	57	HE	1,053
Glover Spring Lake	Callaway	13, 47N, 9W	1.2	67	22	E	863
Indian Hills Lake	Crawford	23, 39N, w	1.0	37	17	E	646

LAKE	COUNTY	LOCATION	SECCHI	TP ¹	Ch1-a ²	TROPIC ³	
						STATE	TN ⁴
Kraut Run Lake (Busch WA #33)	St. Charles	23, 46N, 2E	0.5	99	57	HE	1,140
Lake of the Ozarks (Lower)	Miller	19, 40N, 15W	1.8	30	15	E	625
Lake of the Ozarks(Mid)	Camden			44	16	E	618
Lake Northwoods	Gasconade	33, 43N, w	0.9	27	5	M	482
Lake St. Louis	St. Charles	SW26,47N,2E	0.5	84	22	E	1,164
Lake Tishomingo	Jefferson	5, 41N, 4E	1.8	23	6	M	501
Lake Wauwanoka	Jefferson	1, 40N, 4E	2.6	14	3	M	642
Lincoln Lake	Lincoln	8, 49N, 1E	2.1	20	6	M	487
Little Prairie Lake	Phelps	21, 38N, 7W	0.8	33	9	M	544
Pinnacle Lake	Montgomery	24, 47N w	2.6	24	5	M	463
Pleasant Valley	Gasconade	25, 42N, 6W	1.3	39	31	E	887
Pomme de Terre Lake	Hickory	2, 36N, 22W	1.7	30	15	E	569
Stockton Lake	Cedar	15, 34N, 26W	2.8	14	6	M	432
<u>OZARK HIGHLANDS</u>							
Austin Lake	Texas	30, 29N, 11W	1.7	21	7	M	503
*Bella Vista Lake	Cape Girardeau	15, 32N, 13E	1.4	23	12	M	552
*Boutin Lake	Cape Girardeau	15, 32N, 14E	1.5	23	8	M	558
Bull Shoals Lake	Taney	22N, 20W	2.0	19	8	M	355
Clearwater Lake	Reynolds	6, 28N, 3E	1.9	15	5	M	243
Council Bluff Lake	Iron	23, 35N, 1E	3.2	8	2	O	255
Crane Lake	Iron	33,32N,4E	1.1	16	4	M	263
Fellows Lake	Greene	22, 30N, 21W	2.5	15	5	M	350
Fourche Lake	Ripley	22, 23N, 1W	3.6	10	3	M	252
Fredericktown City (Lake)	Madison	6, 33N, 7E	0.7	65	33	E	752
Goose Creek Lake	St. Francois	26, 38N, 6E	2.0	15	5	M	402
*Lake Capri	St. Francois	30, 37N, 4E	4.4	8	2	O	305
*Lake Carmel	St. Francois	18, 37N, 4E	2.8	10	3	O	331
Lake Forest,(Lake Ann)	St. Genevieve	36, 38N, 7E	1.3	43	22	E	655
Lake Girardeau	Cape Girardeau	9, 30N, 11E	0.7	73	50	E	1,011
Lake Killarney	Iron	1, 33N, 4E	0.8	68	32	E	655
*Lake Marseilles	St. Francois	29, 37N, 4E	3.7	11	2	O	351
*Lake Pinewoods	Carter	7,26N,3E	1.3	45	26	E	858
Lake Springfield	Greene	20, 61N, 16W	1.0	60	19	E	1,016
Lake Taneycomo	Taney	8, 23N, 20W	3.5	23	3	M	803
Lake Turner (Ziske)	Dent	17, 34N, 07W		20	18	E	
Lake Wapapello	Wayne	3, 26N, 3E	1.1	35	20	E	490
Loggers Lake	Dent	10, 31N, 3W	3.1	10	4	M	237
Lower Taum Sauk	Reynolds	33, 33N, 2E	2.1	13	4	M	201
*Macs Lake	Dent		1.4	25	23	E	622
McDaniel Lake	Greene	26, 30N, 22W	1.5	34	17	E	490
*Miller Lake	Carter	1, 27N, 1E	1.5	19	6	M	469
Monsanto Lake (St. Joe State Park)	St. Francois	20, 36N, 5E	2.3	10	2	O	383
Noblett Lake	Douglas	25, 26N, 11W	2.6	18	5	M	255
Norfork Lake	Ozark	21N, 12W	1.7	23	6	M	631
Perry Co. Lake	Perry	22, 35N, 10E	0.7	71	44	E	1,080
Pomona Lake	Howell	26, 26N, 9W		50	10	E	605

<u>LAKE</u>	<u>COUNTY</u>	<u>LOCATION</u>	<u>SECCHI</u>	<u>TP</u> ¹	<u>Ch1-a</u> ²	<u>TROPHIC</u> ³ <u>STATE</u>	<u>TN</u> ⁴
Ripley Co. Lake	Ripley	10, 23N, 1E	1.5	32	26	E	787
Roby Lake	Texas	3, 32N, 11W	2.1	18	5	M	431
*Shane Lake	Dent		2.8	7	1	O	314
*Shawnee Lake	Dent		1.6	30	25	E	610
Sims Valley Lake	Texas	17, 27N, 8W	1.0	28	13	M	512
Sunnen Lake	Washington	4, 37N, 1E	2.6	14	4	M	290
Table Rock Lake	Stone	22, 22N, 22W	3.0	12	6	M	416
Timberline Lake	St. Francois	23, 38N, 04E	3.7	10	2	O	315
Wanda Lee Lake	St. Genevieve	2, 37N, 76	1.4	55	25	E	573

SOUTHEASTERN LOWLANDS

Tywappity Lake	Scott	8, 29N, 13E	0.8	50	36	E	1,005
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¹Total Phosphorus (UG/L)

Secchi depth in meters

²Chlorophyll A (MG/Cubic Meter)

³Trophic State: O=Oligotrophic, M=Mesotrophic, E=Eutrophic, HE=Hypereutrophic

⁴Total Nitrogen (UG/L)

*Unclassified Lake

Trophic status correlates strongly with physiographic region of the state. In agricultural northern and western Missouri, most lakes of known trophic state are eutrophic, while in the Ozarks and ozark border regions, trophic state is equally divided between eutrophic and either mesotrophic or oligotrophic lakes.

All known hypereutrophic lakes are in glaciated northern Missouri, while all oligotrophic lakes are in unglaciated, highly weathered Ozark terrain.

The method presently used by the state to determine trophic status was derived from the work by Wetzel, R.G., 1975; "Limnology," Table 14-11; and from Vollenweider, R.A. and J.J. Kerekes, 1980. EPA440/5-81-010; "Restoration of Lakes and Inland Waters." The criteria are shown in the table below.

TABLE 9. DEFINITION OF TROPHIC CLASSIFICATION

Trophic Class	Chlorophyll-A (ug/l)	Total phosphorus (ug/l)
Oligotrophic	<3	<10
Mesotrophic	3-10	10-30
Eutrophic	11-56	31-100
Hypereutrophic	>56	>100

STATUS OF WETLANDS

Originally about 4.8 million acres (10.7 percent of the land surface of the state) in Missouri were wetlands. By 1980 this figure had been reduced to about 643,000 acres. Several state and federal programs have recognized the need to preserve and enhance our remaining wetlands.

The Missouri Department of Conservation between 1989 and 1997 has purchased 25,000 acres of wetlands and developed new wetland areas on an additional 16,000 acres.

The U.S. Fish and Wildlife Service has begun acquiring land from willing sellers in the Missouri River floodplain for a new national wildlife refuge called Big Muddy. The project authorizes the purchase of up to 16,000 acres in 7 locations. [As of September, 1998, the refuge consisted of 6,186 acres of land in 7 units. The Big Muddy Refuge also administers another 992 acre tract of land in the Missouri floodplain, Overton Bottoms, owned by the US Army Corps of Engineers.](#) Almost all of this acreage is in the Missouri River floodplain and lands will be allowed to interact naturally with the river and act as seasonal wetlands.

The Natural Resource Conservation Service Wetlands Reserve Program begun in 1992, purchases easements of wetlands and provides funds for restoration of those wetlands. There are presently 482 easements on 66,012 acres are in place and an addition of 31 easements on 5,400 acres is in progress.

CHAPTER 4. GROUND WATER ASSESSMENT

BACKGROUND

Somewhat less than half of the people in Missouri rely on ground water as the source of their drinking water. Ground water is the major source of drinking water in the Ozarks and the Southeast Lowlands for both public and private supplies. The cities of Independence, Columbia and St. Charles use ground water adjacent to the Missouri River. In the plains region of the state, many small communities are able to obtain adequate water from shallow alluvial wells near rivers or large creeks, and many individual households still rely on the upland shallow aquifer even though it yields only very small amounts of water.

In the Ozarks, ground water yields are usually large and of excellent quality, as witnessed by the fact that unlike cities in other areas of the state, many municipalities pump ground water directly into their water supplies without treatment. However, the geologic character of the Ozarks, which supplies it with such an abundance of ground water, namely its ability to funnel large amounts of rainfall and surface runoff to the ground water system, can present problems with ground water quality. This is because much surface water flows directly to ground water through cracks, fractures or solution cavities in the bedrock with little or no filtration. Contaminants in leaking septic tanks, storage tanks and surface waters affected by domestic wastewater, animal feedlots and other pollution sources can move directly into ground water through these cavities in the bedrock.

Like the Ozarks, ground water in the southeast lowlands is abundant and of good quality. Unlike the Ozarks, contaminants are filtered by thick deposits of sand, silt and clay as they move through the ground water system. Thus, while shallow ground water wells are subject to the same problems as found locally in the Ozark aquifer, elevated levels of nitrate or bacteria, and can also have low levels of pesticides, deep wells are generally unaffected by contaminants.

Shallow ground water in the plains of northern and western Missouri tends to be somewhat more mineralized and to have taste and odor problems due to high levels of iron and manganese. Like shallow wells in the southeast lowlands, wells in this part of the state can be affected by nitrates, bacteria or pesticides.

In urban areas, alluvial aquifers of large rivers such as the Missouri and the Meramec that serve water supplies have been locally contaminated by spills or improper disposal of industrial or commercial chemicals.

WELL CONSTRUCTION AND GROUND WATER QUALITY

Well water quality is greatly influenced by well construction. Public drinking water wells and many private wells are deep, properly cased and grouted. These wells rarely have contaminants. However, many private wells are shallow or not properly cased. These wells can be easily contaminated by septic tanks, feedlots or chemical mixing sites near the well. Studies in Missouri have shown that two-thirds of wells contaminated by pesticides are less than 35 feet deep. The three most common problems in private wells are bacteria, nitrate and pesticides. It is estimated that about 30 percent of private wells occasionally exceed drinking water standards for bacteria, 30 percent for nitrate and about 5 percent for pesticides. State regulations include standards for construction and wellhead protection for all new wells.

MAJOR POTABLE AQUIFERS IN MISSOURI

The location of the major aquifers providing drinkable water in Missouri are shown below. The unconfined aquifers are those under water table conditions (the pressure at the water table is the atmospheric pressure). These unconfined aquifers tend to yield greater amounts of water, but are also more easily contaminated by activities occurring at the land surface. In confined aquifers, the upper level of the saturated zone is restricted so that the pressure level is greater than exists at that level of saturation. Confined aquifers are generally recharged more slowly than unconfined aquifers but are better protected from surface contaminants.

Glacial Till Aquifer

This aquifer covers most of the Missouri north of the Missouri River. Glacial till is an unsorted mixture of clay, sand and gravel with occasional boulders and lenses of sand or gravel. Loess, fine wind-blown silt deposits of four to eight feet in depth, cover the till on the uplands. In places, the till is underlain by sorted deposits of sand or gravel. Although this aquifer is unconfined, surface water infiltrates very slowly, and ground water yields are very small. In scattered areas the till has buried old river channels that remain as large sand or gravel deposits that contain much more ground water than the till.

Some households still rely on this aquifer for drinking water, but it is inadequate as a source for municipal water supply.

Alluvial Aquifer

Alluvial aquifers are the unconfined aquifers on floodplains of rivers and are of Quaternary age. In Missouri, the largest of these aquifers lie along the Missouri and Mississippi rivers, reaching their widest extent in the southeast lowlands where they extend for as much as 50 miles west of the Mississippi River. Many small communities north of the Missouri River use the alluvial aquifers of nearby streams for their drinking water supply, and the Missouri River alluvium supplies the cities of Independence and Columbia and sections of St. Charles County. In the southeast lowlands, most private water supplies and about 45 percent of people served by public water supplies use water from the alluvial aquifer. Agricultural irrigation consumes about five times more water in this area of Missouri than does domestic water use. All agricultural irrigation water is drawn from the alluvial aquifer.

Wilcox-McNairy Aquifer

These two aquifers lie beneath much of the alluvial aquifer of the southeast lowlands. They are in unconsolidated or loosely consolidated deposits of marine sands and clays of Tertiary and Cretaceous age. Except where the McNairy outcrops in the Benton Hills and along Crowley's Ridge, these aquifers are confined. They yield abundant amounts of good quality water, and they provide the water for 55 percent of people served by public supplies. In the southeastern part of this region, the deeper of these aquifers, the McNairy, becomes too mineralized to be used for drinking water supply. These two aquifers appear to be unaffected by contaminants of human origin.

Ozark-St. Francis Aquifer

This aquifer covers most of the southern and central two-thirds of Missouri. It is composed of dolomites and sandstones of Ordovician and Cambrian age. Most of the aquifer is unconfined. This aquifer is used for almost all public and private drinking water supplies in this area of Missouri. Exceptions would include supplies in the St. Francis Mountains, such as Fredericktown and Ironton, where the aquifer has been lost due to geologic uplift and erosion, and in Springfield, where demand is so heavy that ground waters are supplemented with water from two

reservoirs and the James River.

Yields and water quality are typically very good, but in many areas, the bedrock is highly weathered, contains many solution cavities and can transmit contaminated surface waters into the ground water rapidly with little or no filtration. Where the confined portion of the aquifer is overlain only by the Mississippian limestones of the Springfield aquifer, the confined Ozark aquifer continues westward for 80 miles or more as a potable water supply, serving the communities of Pittsburg, Kansas, and Miami, Oklahoma. However, where it is also overlain by less permeable Pennsylvanian bedrock, the confined Ozark becomes too mineralized for drinking within 20 to 40 miles.

The unconfined Ozark-St. Francis aquifer is susceptible to contamination from surface sources. Increasing urbanization and increasing numbers of livestock are threats to the integrity of portions of this valuable aquifer.

Springfield Aquifer

This aquifer covers a large portion of southwestern Missouri. It is composed of Mississippian limestones that are, particularly in the eastern portion of the aquifer, highly weathered. The aquifer is unconfined and surface water in many areas is readily transmitted to ground water. Urbanization and livestock production affect this aquifer. Elevated nitrates and bacterial contamination are common problems in ground waters of the Springfield aquifer.

GROUNDWATER QUALITY SUMMARY TABLES

Table 10 lists the major sources of ground water contamination in Missouri, major contaminants and reasons why these sources are the most important. Table 11 summarizes groundwater quality problems as hazardous waste sites. Tables 12 and 13 provide information on levels of nitrate, pesticides and other toxic organics in public drinking water wells and Table 14 gives the present status of Missouri's groundwater protection strategy.

TABLE 10. MAJOR SOURCES OF GROUND WATER CONTAMINATION

Contaminant Source	10 Highest Priority Sources (X) ⁽¹⁾	Factors Considered in Selecting a Contaminant Source ⁽²⁾	Contaminants ⁽³⁾
Agricultural Activities			
Agricultural chemical facilities			
Animal feedlots			
Drainage wells			
Fertilizer applications	X	A,C,D,E	E
Irrigation practices			
Pesticide applications	X	A,B,C,D,E	B
Storage and Treatment Activities			
Land application	X	A,D,E	J,K,L,E
Material stockpiles			
Storage tanks (above ground)			
Storage tanks (underground)	X	A,B,C,D,E	D
Surface impoundments			
Waste piles			
Waste tailings			
Disposal Activities			
Deep injection wells			
Landfills			
Septic systems	X	A,D,E	J,K,L,E
Shallow injection wells			
Other			
Hazardous waste generators			
Hazardous waste sites	X	A,B,C,D	B,C,H,I
Industrial facilities	X	A,B,C,E	E,Ammonia, PCP, Dioxin
Material transfer operations			
Mining and mine drainage	X	A,E	H
Pipelines and sewer lines			

Contaminant Source	10 Highest Priority Sources (X) ⁽¹⁾	Factors Considered in Selecting a Contaminant Source ⁽²⁾	Contaminants ⁽³⁾
Salt storage and road salting			
Salt water intrusion	X	C	G
Spills	X	A,B,C,E	B,C,D,Ammonia
Transportation of materials			
Urban runoff			
Other sources (please specify)			
Other sources (please specify)			

(1) Not in Priority Order

(2) Key: Factors Considered in Selecting Contaminant Source.

- A. Human health or environmental toxicity risk
- B. Size of population at risk
- C. Location of sources relative to drinking water sources
- D. Number and/or size of contaminant sources
- E. Hydrogeologic sensitivity

(3) Key: Contaminants

- | | |
|-------------------------|-------------------|
| A. Inorganic Pesticides | G. Salinity/brine |
| B. Organic Pesticides | H. Metals |
| C. Halogenated Solvents | I. Radionuclides |
| D. Petroleum compounds | J. Bacteria |
| E. Nitrate | K. Protozoa |
| F. Fluoride | L. Viruses |

TABLE 11. GROUND WATER CONTAMINATION SUMMARY

Hydrogeologic Setting⁽¹⁾ All Aquifers
 Spatial Description (optional)⁽²⁾
 Map Available (optional)⁽³⁾
 Data Reporting Period⁽⁴⁾ Sept.1997- Sept.1999

Source Type ⁽⁵⁾	Number of sites ⁽⁶⁾	Number of sites that are listed and/or have confirmed releases ⁽⁶⁾	Number with confirmed ground water contamination ⁽⁶⁾	Contaminants ⁽⁷⁾	Number of site investigations (optional)	Number of sites that have been stabilized or have had the source removed (optional)	Number of sites with corrective action plans (optional)	Number of sites with active remediation (optional)	Number of sites with cleanup completed (optional)
NPL	18	18	13	5	23	12	13	9	6
CERCLIS (non-NPL)	51	51	14	7	36	19	32	10	16
DOD/DOE	27	25	11	*6					
LUST	840	840	250	1	141			508	332
RCRA Corrective Action	96	53	43	2	48	29	33	20	6
Underground Injection									
State Sites	33	33	19	3	11	11	8	10	5
Nonpoint Sources ⁽⁵⁾									
Other (specify)									

NPL - National Priority List , DOE- Department of Energy ; DOD- Department of Defense; CERCLIS (non-NPL) - Comprehensive Environmental Response, Compensation, and Liability Information System; LUST - Leaking Underground Storage Tanks; RCRA - Resource Conservation and Recovery Act.

* Contaminants

*1 - BTEX, TPH, MTBE, PAH, Metals, SVOA;*2 - Creosote, penta, Organic Solvents, Petroleum, Asbestos, Metals, Chlorinated Solvents

*3 - VOC, PAH, Chlorinated Solvents, Metals;*4 - VOA, PCB, Pesticides, Dioxin, Metals, Radionuclides, SVOCs, etc.

*5 - VOAs, SVOAs, PCBs, Dioxin, PAH, Pesticides, Metals;*6 - Radionuclides, Metals, Semo-volatiles, Volatiles, Pesticides, Explosives

TABLE 12. AQUIFER MONITORING DATA

Hydrogeologic Setting ⁽¹⁾	All Aquifers
Spatial Description (optional) ⁽²⁾	State-wide, most are in southern half of the state
Map Available (optional) ⁽³⁾	
Data Reporting Period ⁽⁴⁾	1996-97

Monitoring Data Type	Total No. Of Wells Used in the Assessment ⁽⁵⁾	Parameter Groups	NUMBER OF WELLS								
			No detections of parameters above MDLs or background levels		Nitrate concentrations range from background levels to less than or equal to 5 mg/l		nitrate ranges from greater than 5 to less than or equal to 10 mg/l				
					No detections of parameters other than nitrate above MDLs or background levels and/or located in areas that are sensitive or vulnerable						
				Number of wells in sensitive or vulnerable areas (optional)	Nitrate ≤ 5 mg/l VOC, SOC, and Other parameters not detected	Number of wells in sensitive or vulnerable areas (optional)	Other parameters are detected at concentrations exceeding the MDL but are less than or equal to the MCLs	Parameters are detected at concentrations exceeding the MCLs	Number of Wells Removed from service	Number of Wells Requiring Special Treatment	Background parameters exceed MCLs
Ambient Monitoring Network (Optional)		VOC									
		SOC									
		NO ₃									
		Other									
Untreated Water Quality Data from Public Water Supply Wells	220	VOC									
		SOC									
		NO ₃									
		Other*	219	29**		1				***	
Finished Water Quality Data from Public Water Supply Wells	38	VOC			29		9				
	172	SOC									
		NO ₃	170		2						
		Other									

*Human Enteric Virus; ** Wells in primary karst (more than 10 sinkholes/100 sq. mi.); *** No MCLs established.

MDL = maximum daily level, SOC = synthetic organic compound, MCL = maximum contaminant level, NO₃ = nitrate, VOC = volatile organic compound, ND = not detected.

TABLE 13. AQUIFER MONITORING DATA

Hydrogeologic Setting
 Spatial Description (optional)
 Map Available (optional)
 Data Reporting Period

All Aquifers

Sept. 1997-Sept.1999

Monitoring Data Type	Total No. Of Wells Used in the Assessment ⁽⁵⁾	Parameter Groups	NUMBER OF WELLS								
			No detections of parameters above MDLs or background levels		Nitrate concentrations range from background levels to less than or equal to 5 mg/l		Nitrate ranges from greater than 5 to less than or equal to 10 mg/l				
					No detections of parameters other than nitrate above MDLs or background levels and/or located in areas that are sensitive or vulnerable						
						Number of wells in sensitive or vulnerable areas (optional)					
			ND		VOC, SOC, and Other parameters not detected		Other parameters are detected at concentrations exceeding the MDL but are less than or equal to the MCLs	Parameters are detected at concentrations exceeding the MCLs	Number of Wells Removed from service	Number of Wells Requiring Special Treatment	Background parameters exceed MCLs
Ambient Monitoring Network (Optional)		VOC									
		SOC									
		NO ₃									
		Other ⁽¹⁵⁾									
Untreated Water Quality Data from Public Water Supply Wells		VOC									
		SOC									
		NO ₃									
		Other ⁽¹⁵⁾									
Finished Water Quality Data from Public Water Supply Wells	2926	VOCs					11	1	3		
		SOCs					3		1		
		NO3	1536		1371		16	3	2		
		Other ⁽¹⁵⁾									

MDL = maximum daily level
 MCL = maximum contaminant level
 VOC = volatile organic compound

SOC = synthetic organic compound
 NO₃ = nitrate
 ND = not detected

SUMMARY OF GROUND WATER PROTECTION PROGRAMS

TABLE 14. GROUND WATER PROTECTION STRATEGY

Program or Activities	Check (X)	Implementation Status	Responsible State Agency
Active SARA Title III Program	X		MDPS/SEMA
Ambient ground water monitoring system		NA	
Ground water monitoring at sanitary landfills	X	Fully established	DNR
Aquifer vulnerability assessment	X		DNR
Aquifer mapping		NA	
Aquifer characterization		NA	
Comprehensive data management system		NA	
EPA-endorsed Core Comprehensive State Ground Water Protection Program (CSGWPP)		Under development	DNR
Ground water discharge permits	X	Fully established	DNR
Ground water best management practices (BMPs)	X	Continuing effort	DNR
Ground water legislation	X		DNR
Ground water classification		NA	
Ground water quality standards	X	Fully established	DNR
Interagency coordination for ground water protection initiatives	X	Fully established	DNR*
Nonpoint source controls		Continuing effort	DNR*
Pesticide State Management Plan		Pending	MDA
Pollution Prevention Program		Pending	DNR
Resource Conservation and Recovery Act (RCRA) Primacy	X	Fully established	DNR
State Superfund	X	Fully established	DNR
State RCRA Program incorporating more stringent requirements than RCRA Primacy	X	Fully established	DNR
State septic system regulations	X	Fully established	MDH
Underground storage tank installation requirements	X	Fully established	DNR
Underground Storage Tank Remediation Fund	X	Pending	DNR
Underground Storage Tank Permit Program		NA	
Underground Injection Control Program	X	Fully established	DNR
Vulnerability assessment for drinking water/wellhead protection	X	Fully established	DNR
Well abandonment regulations	X	Fully established	DNR
Wellhead Protection Program (EPA-approved)	X	Fully established	DNR
Well installation regulations	X	Fully established	DNR

MDPS/SEMA = Missouri Department of Public Safety, State Emergency Management Agency
MDA = Missouri Department of Agriculture
MDH = Missouri Department of Health

Notes:

Active SARA Title III Program: Administered by Department of Public Safety, State Emergency Management Agency.

Ambient ground water monitoring system: There is no system per se. The state has participated in several opportunities to monitor ambient ground water, such as impact analyses following the floods of 1993.

Aquifer vulnerability assessment: These are conducted by the department's Division of Geology & Land Survey on a county-by-county basis as funding allows.

Aquifer mapping and characterization: No present systematic activity, although these activities may be conducted in concert with hazardous substance release investigations.

Comprehensive data management system: None.

EPA-endorsed Core Comprehensive State Ground Water Protection Program: No formal program established.

Ground water discharge permits: Underground Injection Control permits issued jointly by the department's Division of Geology & Land Survey and Water Pollution Control Program.

Ground Water Best Management Practices: Some BMPs are established as part of the Nonpoint Source Management Plan.

Ground water legislation: The Cave Resources Act and Clean Water Law deal directly with ground water. Other laws such as the dead animal disposal statute proscribe protections for ground water. There is no comprehensive ground water protection statute per se.

Ground water classification: None, although a utilities group proposed a classification system.

Ground water quality standards: Established as part of state water quality standards.

Interagency coordination for ground water protection initiatives: Opportunities for monthly coordination are provided through the Water Quality Coordinating Committee.

Nonpoint source controls: The nonpoint source management program provides guidance for voluntary controls.

Pesticide State Management Program: A draft generic pesticides and water quality management plan has been prepared by the Department of Agriculture in conjunction with DNR. The plan will address both ground water and surface water, and has been submitted to EPA for approval.

Pollution Prevention Program: Some activities carried out by one staff member in the department's Technical Assistance Program; budget request for six full time employees proposed for FY97 budget.

Resource Conservation and Recovery Act (RCRA) Primacy: Administered by the department's Hazardous Waste Program.

State Superfund: Administered by the department's Hazardous Waste Program. This provides for a state registry of confirmed abandoned hazardous waste disposal sites.

State RCRA Program: Incorporating more stringent requirements than RCRA Primacy: Administered by the

department's Hazardous Waste Program.

State septic system regulations: Administered by the Department of Health under 1994 statute and rules promulgated in 1995.

Underground storage tank installation requirements: Administered by the department's Hazardous Waste Program.

Underground Storage Tank Remediation Fund: The existing insurance fund was converted to a remediation fund by 1995 statute; rules are being prepared.

Underground Storage Tank Permit Program: Tanks are required to be registered but not permitted.

Underground Injection Control Program: Administered by the department's Division of Geology & Land Survey.

Vulnerability assessment for drinking water/wellhead protection: Administered by the department's Public Drinking Water Program.

Well abandonment regulations: Administered by the department's Division of Geology & Land Survey.

Wellhead Protection Program (EPA-approved): Administered by the department's Public Drinking Water Program.

Well installation regulations: Administered by the department's Division of Geology & Land Survey.

The significant additions or changes to the protection of ground water in the past two years are the passage of two statutes, SB 446 in 1994 and HB 251 in 1995. The former revised requirements for onsite sewage systems and the latter established a \$100 million remedial fund for underground storage tanks. Each was a revision of an existing statute.

For more information, call the Department of Natural Resources at (573) 751-1300.